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Anchorage Effectiveness of Orthodontic Miniscrews compared to Headgear and Transpalatal Arches: A Systematic Review and Meta-Analysis

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Key words: systematic review, orthodontics, miniscrews, headgear, transpalatal arch, anchorage

Anchorage Effectiveness of Orthodontic Miniscrews compared to Headgear and Transpalatal Arches: A Systematic Review and Meta-Analysis

Introduction

Anchorage by definition is the resistance to unwanted tooth movement { ADDIN EN.CITE

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Sciences</publisher><isbn>0323078184</isbn><urls></urls></record></Cite></End Note>}. Orthodontic anchorage, conventionally, has been provided by different methods including incorporating multiple teeth, or use of headgear, face masks, chin caps, transpalatal arches (including Nance buttons), lingual arches or intermaxillary elastics { ADDIN EN.CITE

<EndNote><Cite><Author>Wahl</Author><Year>2008</Year><RecNum>2</RecNum><DisplayText>(2)</DisplayText><record><rec-number>2</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">2</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Wahl, Norman</author></authors></contributors><titles><title>Orthodontics in 3 millennia. Chapter 15: Skeletal anchorage</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-title></titles><periodical><full-title>American Journal of Orthodontics and Dentofacial Orthopedics</full-title></periodical><pages>707-

r></dates><isbn>0003-3219</isbn><urls></urls></record></Cite></EndNote>}.
</EndNote></Cite></EndNote>}

Skeletal anchorage devices can be defined as the use of implants, plates, screws or screw-retained devices inserted into bone to provide resistance to unwanted tooth movement (indirect anchorage) or a point from which orthodontic traction can be applied (direct anchorage) { ADDIN EN.CITE

<EndNote><Cite><Author>Ödman</Author><Year>1994</Year><RecNum>5</RecNum><DisplayText>(5)</DisplayText><record><rec-number>5</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">5</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ödman,

Jan</author><author>Lekholm, Ulf</author><author>Jemt, Torsten</author><author>Thilander,

Birgit</author></authors></contributors><titles><title>Osseointegrated implants as orthodontic anchorage in the treatment of partially edentulous adult patients</title><secondary-title>The European Journal of Orthodontics</secondary-title></titles><periodical><full-title>The European Journal of Orthodontics</full-title></periodical><pages>187-

201</pages><volume>16</volume><number>3</number><dates><year>1994</year>r></dates><isbn>0141-5387</isbn><urls></urls></record></Cite></EndNote>}. It

can broadly be divided into two categories: osseointegrated implants such as mid-palatal implants { ADDIN EN.CITE

<EndNote><Cite><Author>Wehrbein</Author><Year>1999</Year><RecNum>6</RecNum><DisplayText>(6)</DisplayText><record><rec-number>6</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">6</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Wehrbein,

Heinrich</author><author>Merz, Beat R</author><author>Diedrich, Peter</author></authors></contributors><titles><title>Palatal bone support for orthodontic implant anchorage-a clinical and radiological study</title><secondary-title>The European Journal of Orthodontics</secondary-title></titles><periodical><full-title>The European Journal of Orthodontics</full-

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 S</author><author>Hoffman, David
 R</author></authors></contributors><titles><title>A new device for absolute
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 258</pages><volume>107</volume><number>3</number><dates><year>1995</ye
 ar></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>},
 and mechanically retained devices such as titanium mini-plates { ADDIN EN.CITE
 <EndNote><Cite><Author>De
 Clerck</Author><Year>2009</Year><RecNum>8</RecNum><DisplayText>(8)</Displ
 ayText><record><rec-number>8</rec-number><foreign-keys><key app="EN" db-
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 journal of the American Association of Oral and Maxillofacial Surgeons</secondary-
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title></periodical><pages>2123</pages><volume>67</volume><number>10</number><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>},

zygomatic wires and miniscrews { ADDIN EN.CITE

<EndNote><Cite><Author>Kuroda</Author><Year>2007</Year><RecNum>9</RecNum><DisplayText>(9, 10)</DisplayText><record><rec-number>9</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">9</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Kuroda, Shingo</author><author>Sugawara, Yasuyo</author><author>Deguchi, Toru</author><author>Kyung, Hee-Moon</author><author>Takano-Yamamoto, Teruko</author></authors></contributors><titles><title>Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-title></titles><periodical><full-title>American Journal of Orthodontics and Dentofacial Orthopedics</full-title></periodical><pages>9-15</pages><volume>131</volume><number>1</number><dates><year>2007</year></dates><isbn>0889-5406</isbn><urls></urls></record></Cite><Cite><Author>Cope</Author><Year>2005</Year><RecNum>10</RecNum><record><rec-number>10</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">10</key></foreign-keys><ref-type name="Conference Proceedings">10</ref-type><contributors><authors><author>Cope, Jason B</author></authors></contributors><titles><title>Temporary anchorage devices in orthodontics: a paradigm shift</title><secondary-title>Seminars in Orthodontics</secondary-title></titles><pages>3-9</pages><volume>11</volume><number>1</number><dates><year>2005</year></dates><publisher>Elsevier</publisher><isbn>1073-8746</isbn><urls></urls></record></Cite></EndNote>}. The use of miniscrews has increased in orthodontics due to their ease of insertion and removal, reasonable cost, biocompatibility and capability to withstand orthodontic forces { ADDIN EN.CITE

<EndNote><Cite><Author>Cousley</Author><Year>2015</Year><RecNum>11</Rec

Num><DisplayText>(11, 12)</DisplayText><record><rec-number>11</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">11</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Cousley, RRJ</author><author>Sandler, PJ</author></authors></contributors><titles><title>Advances in orthodontic anchorage with the use of mini-implant techniques</title><secondary-title>British dental journal</secondary-title></titles><periodical><full-title>British dental journal</full-title></periodical><pages>E4-E4</pages><volume>218</volume><number>3</number><dates><year>2015</year></dates><isbn>0007-0610</isbn><urls></urls></record></Cite><Cite><Author>Prabhu</Author><Year>2006</Year><RecNum>12</RecNum><record><rec-number>12</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">12</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Prabhu, Jagadish</author><author>Cousley, Richard RJ</author></authors></contributors><titles><title>Current Products and Practice Bone anchorage devices in orthodontics</title><secondary-title>Journal of Orthodontics</secondary-title></titles><periodical><full-title>Journal of Orthodontics</full-title></periodical><pages>288-307</pages><volume>33</volume><number>4</number><dates><year>2006</year></dates><isbn>1465-3125</isbn><urls></urls></record></Cite></EndNote>}.
Recent reviews investigated the effectiveness of all types of skeletal anchorage devices in anchorage provision in relation to conventional methods { ADDIN EN.CITE <EndNote><Cite><Author>Jambi</Author><Year>2014</Year><RecNum>13</RecNum><DisplayText>(13, 14)</DisplayText><record><rec-number>13</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202"

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However, the findings of these reviews were not specific to the most commonly used skeletal anchorage device, the mechanically retained miniscrews. The aim of this review therefore was to systematically review the effectiveness of miniscrews in reinforcing anchorage during En-masse retraction of anterior teeth.

Methods

Protocol registration, conflict of interest, and funding

This review received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The study protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) under protocol number (CRD 42017071439). The study was planned and reported accordingly with the preferred reporting items for systematic review and meta-analysis { ADDIN EN.CITE

<EndNote><Cite><Author>Moher</Author><Year>2009</Year><RecNum>15</RecNum><DisplayText>(15)</DisplayText><record><rec-number>15</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">15</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Moher, David</author><author>Liberati, Alessandro</author><author>Tetzlaff, Jennifer</author><author>Altman, Douglas G</author><author>Prisma Group</author></authors></contributors><titles><title>Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement</title><secondary-title>PLoS medicine</secondary-title></titles><periodical><full-title>PLoS medicine</full-title></periodical><pages>e1000097</pages><volume>6</volume><number>7</number><dates><year>2009</year></dates><isbn>1549-1676</isbn><urls></urls></record></Cite></EndNote>} and Cochrane Guidelines for Systematic Reviews { ADDIN EN.CITE <EndNote><Cite><Author>Higgins</Author><Year>2011</Year><RecNum>16</RecNum><DisplayText>(16)</DisplayText><record><rec-number>16</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">16</key></foreign-keys><ref-type name="Book">6</ref-type><contributors><authors><author>Higgins, Julian PT</author><author>Green, Sally</author></authors></contributors><titles><title>Cochrane handbook for systematic reviews of

interventions</title></titles><volume>4</volume><dates><year>2011</year></dates><publisher>John Wiley & Sons</publisher><isbn>1119964792</isbn><urls></urls></record></Cite></EndNote>}.
 ADDIN EN.CITE <EndNote><Cite ExcludeYear="1"><Author>Al-Sibaie</Author><Year>2013</Year><RecNum>17</RecNum><DisplayText>(17)</DisplayText><record><rec-number>17</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">17</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Al-Sibaie, Salma</author><author>Hajeer, Mohammad Y</author></authors></contributors><titles><title>Assessment of changes following en-masse retraction with mini-implants anchorage compared to two-step retraction with conventional anchorage in patients with class II division 1 malocclusion: a randomized controlled trial</title><secondary-title>European journal of orthodontics</secondary-title></titles><periodical><full-title>European journal of orthodontics</full-title></periodical><pages>275-283</pages><volume>36</volume><number>3</number><dates><year>2013</year></dates><isbn>1460-2210</isbn><urls></urls></record></Cite></EndNote>}.
 Secondary outcomes including the treatment and space closure duration, number of

Eligibility criteria

Participants: Participants of any age or gender required En-masse retraction of anterior teeth, using fixed orthodontic appliances combined with extraction of maxillary premolars, treated in general practitioner/specialist offices or hospital settings were included.

Interventions: Participants who required orthodontic anchorage reinforcement by mechanically-retained miniscrews of any length but a diameter of 2 mm or less.

Comparators: Participants required anchorage reinforcement using headgear, Nance appliance, transpalatal arch appliances or any other conventional anchorage appliances.

Outcome measures: The primary outcome was the anchorage loss defined as amount of mesial movement of the upper first permanent molar, measured in millimetres {

ADDIN EN.CITE <EndNote><Cite ExcludeYear="1"><Author>Al-Sibaie</Author><Year>2013</Year><RecNum>17</RecNum><DisplayText>(17)</DisplayText><record><rec-number>17</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">17</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Al-Sibaie, Salma</author><author>Hajeer, Mohammad Y</author></authors></contributors><titles><title>Assessment of changes following en-masse retraction with mini-implants anchorage compared to two-step retraction with conventional anchorage in patients with class II division 1 malocclusion: a randomized controlled trial</title><secondary-title>European journal of orthodontics</secondary-title></titles><periodical><full-title>European journal of orthodontics</full-title></periodical><pages>275-283</pages><volume>36</volume><number>3</number><dates><year>2013</year></dates><isbn>1460-2210</isbn><urls></urls></record></Cite></EndNote>}.
 Secondary outcomes including the treatment and space closure duration, number of

visits, quality of treatment, adverse effects and patient-reported outcomes were collected from the studies when available.

Study design: The included studies in this systematic review were human RCTs published in English. There was no limitation in terms of publication's year, publication status, or publication type. All in vitro studies, animal studies, case reports and case series and review articles were excluded. Language exclusion criteria was applied following the primary search to avoid bias in the search protocol.

Information sources and search strategy

A comprehensive search using a combination of controlled vocabulary and free text terms was designed to identify published, ongoing and unpublished studies (Appendix 1). The following electronic databases were searched up to March 16, 2018: MEDLINE via PubMed; Cochrane Database of Systematic Reviews and Cochrane Central Register of Controlled Trials searched via the Cochrane Library and Scopus. Up to March 7, 2018, a manual search in the leading orthodontic journals and other bibliographic databases were also searched for ongoing and unpublished data (Appendix 1). Reference lists of the included articles and other relevant systematic reviews to this topic were screened for any additional relevant literature and to include an additional controlled vocabulary and free text terms, if present. We assumed that adverse effects are described in included studies only.

Study selection

Electronic database searching was performed independently and in duplicate by two reviewers (FA and MA). A manual search and additional bibliographic databases search were undertaken by one reviewer (DB). Duplicate removal was undertaken using EndNote reference manager software by one reviewer. First, relevant articles were identified through their titles and abstracts. In cases of unclear study design, corresponding authors were contacted for further information. Then, the full text of the potential articles was assessed for eligibility by two reviewers (FA and DB). In the case of disagreement between the reviewers, a consensus was made through open discussion with the third reviewer (MA). All excluded studies were listed with their exclusion justification (Appendix2).

Data extraction

Two reviewers (FA and MA) extracted the data using a pre-piloted standardised data extraction form and the following information was collected: (1) authors, (2) year of publication, (3) study setting, (4) number and age of the participants, (5) miniscrew number and dimensions, (6) types of conventional anchorage appliance, (6) amount of anchorage loss in miniscrew and control group; and (7) any secondary outcomes. In the case of disagreement between the reviewers, a consensus was made through open discussion with the third reviewer (DB). Authors were contacted to clarify data if required for further information.

Assessment of risk bias in the included studies

The included RCTs were assessed for risk of bias by two reviewers (FA and DB), using the Cochrane collaboration's tool, a domain-based tool { ADDIN EN.CITE <EndNote><Cite><Author>Higgins</Author><Year>2011</Year><RecNum>18</RecNum><DisplayText>(18)</DisplayText><record><rec-number>18</rec-

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T</author><author>Altman, Douglas G</author><author>Gøtzsche, Peter

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David</author><author>Oxman, Andrew D</author><author>Savović,

Jelena</author><author>Schulz, Kenneth F</author><author>Weeks,

Laura</author><author>Sterne, Jonathan A

C</author></authors></contributors><titles><title>The Cochrane Collaboration's

tool for assessing risk of bias in randomised trials</title><secondary-

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-urls></urls><electronic-resource-num>10.1136/bmj.d5928</electronic-resource-

num></record></Cite></EndNote>}. Each included study was assessed regarding the

risk of bias in (1) random sequence generation; (2) allocation concealment; (3) blinding

of participants and personnel; (4) blinding of outcome assessors; (5) incomplete outcome data; (6) selective reporting; (7) other sources of bias. In the case of disagreement between the reviewers, a consensus was made through open discussion with the third reviewer (MA).

The overall risk of bias of individual studies was categorised as being at low (if all domains were at low risk of bias), high (if one or more domains were at high risk of bias), or unclear risk of bias (if one or more domains were at unclear risk of bias).

Data synthesis

For continuous data, the standard mean difference (SMD) with its 95% confidence intervals was chosen as a summary effect. Statistical aggregation of the results was carried out using a random-effects of the SMD. A random-effects model was applied to the pooled estimates as it takes into its consideration the possible existence of heterogeneity. The heterogeneity across the studies was assessed using the I^2 and χ^2 statistics. A 25%, 50% and 75% statistic accounts for low, moderate and high levels of heterogeneity respectively.

In the eligible studies with more than two arms, comparisons were made between the miniscrews arm and each of the controlled arms individually according to Cochrane Guidelines for Systematic Reviews { ADDIN EN.CITE <EndNote><Cite><Author>Higgins</Author><Year>2011</Year><RecNum>16</RecNum><DisplayText>(16)</DisplayText><record><rec-number>16</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">16</key></foreign-keys><ref-type name="Book">6</ref-type><contributors><authors><author>Higgins, Julian PT</author><author>Green, Sally</author></authors></contributors><titles><title>Cochrane handbook for systematic reviews of interventions</title></titles><volume>4</volume><dates><year>2011</year></dates><publisher>John Wiley & Sons</publisher><isbn>1119964792</isbn><urls></urls></record></Cite></EndNote>}.

The statistical tests were performed using the Review Manager (RevMan) Version 5.3 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). The

net confidence in the effect estimates and any subsequent clinical recommendations was enhanced by rating the overall quality of the resultant evidence using the GRADE approach.

Additional analysis

The protocol of this review included a visual inspection of a generated contour-enhanced funnel plot if 10 or more studies met the inclusion criteria. Besides, Egger's

linear regression tests { ADDIN EN.CITE
<EndNote><Cite><Author>Egger</Author><Year>1997</Year><RecNum>19</RecNum><DisplayText>(19)</DisplayText><record><rec-number>19</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">19</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Egger, Matthias</author><author>Smith, George Davey</author><author>Schneider, Martin</author><author>Minder, Christoph</author></authors></contributors><titles><title>Bias in meta-analysis detected by a simple, graphical test</title><secondary-title>Bmj</secondary-title></titles><periodical><full-title>BMJ</full-title></periodical><pages>629-634</pages><volume>315</volume><number>7109</number><dates><year>1997</year></dates><isbn>0959-8138</isbn><urls></urls></record></Cite></EndNote>}

were pre-planned to examine publication bias. To investigate the robustness of this review, further sensitivity tests were performed examining the impact of removing

each study on the overall outcome { ADDIN EN.CITE
<EndNote><Cite><Author>Higgins</Author><Year>2011</Year><RecNum>16</RecNum><DisplayText>(16)</DisplayText><record><rec-number>16</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">16</key></foreign-keys><ref-type name="Book">6</ref-type><contributors><authors><author>Higgins, Julian PT</author><author>Green, Sally</author></authors></contributors><titles><title>Cochrane handbook for systematic reviews of

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<p>The initial search strategy identified 751 records (Figure 1). As a result of the initial screening and duplicate removal, 717 records were excluded (5 duplicate studies and the rest were not eligible studies). The full texts of the remaining 34 articles were assessed which led to the exclusion of 27 studies (Appendix 2). The final sample included seven RCTs; { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}, all of them were single centre parallel two-arm trials except the RCT by Sandler and colleagues { ADDIN EN.CITE</p>
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<div data-bbox="144 869 853 888" data-label="Text>
<p>which was a multicentre three-arms parallel trial. Three trials were performed in India</p>
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{ ADDIN EN.CITE { ADDIN EN.CITE.DATA }}, two in China { ADDIN EN.CITE
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 implants or transpalatal arches in adult patients with bialveolar dental
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 5387</isbn><urls></urls></record></Cite></EndNote>}, one in Syria { ADDIN EN.CITE
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r></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}. All of the included RCTs were performed in university settings.

Characteristics of the interventions

Four studies compared miniscrews to transpalatal arch { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}

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20</pages><volume>146</volume><number>1</number><dates><year>2014</yea
r></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}. The
last study compared miniscrews with other methods of conventional anchorage
provision including HG, transpalatal arch , differential moments and the banding of a
second molar { ADDIN EN.CITE
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three-arm trial { ADDIN EN.CITE
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included an additional comparison between miniscrews and Nance appliance (Table 1). The overall number of the participants analysed in the 7 included RCTs were 271 who had been treated using 310 miniscrews and 149 conventional anchorage appliances, however, the outcomes 241 participants treated using 250 miniscrews and 134 conventional anchorage appliances were meta-analysed.

Characteristics of the participants

Two RCTs recruited adolescent participants { ADDIN EN.CITE { ADDIN EN.CITE.DATA }} while the rest recruited adults and young adults. Female participants were dominant in four studies { ADDIN EN.CITE { ADDIN EN.CITE.DATA }} and one study recruited more males than females { ADDIN EN.CITE

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studies included only female participants { ADDIN EN.CITE
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patients: a randomized controlled trial</title><secondary-title>American Journal of
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measured maxillary molar movement from the start of the treatment until a Class I canine relationship was achieved. Two trials { ADDIN EN.CITE <EndNote><Cite><Author>Basha</Author><Year>2010</Year><RecNum>20</RecNum><DisplayText>(20, 25)</DisplayText><record><rec-number>20</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202"

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 e1</pages><volume>134</volume><number>1</number><dates><year>2008</yea
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measured the degree of mesial movement of the molar during space closure phase,
 before the commencement of space closure up to the end of space closure phase. The
 primary outcome was measured from the beginning of the treatment to the end of
 space closure in one study { ADDIN EN.CITE
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 the last trial { ADDIN EN.CITE
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5387</isbn><urls></urls></record></Cite></EndNote>}, the amount of mesial molar movement of the upper first permanent molar was not reported. In five trials { ADDIN

EN.CITE { ADDIN EN.CITE.DATA }}, anchorage loss as primary outcome was measured on cephalometric tracings and the average of the two sides was considered. However, in one trial { ADDIN EN.CITE <EndNote><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><DisplayText>(23)</DisplayText><record><rec-number>23</rec-

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20</pages><volume>146</volume><number>1</number><dates><year>2014</year></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}, left and right mesial molar movements were measured individually, therefore, we calculated the average of both sides for ease of meta-analysis.

Secondary outcomes

Two studies { ADDIN EN.CITE <EndNote><Cite><Author>Liu</Author><Year>2009</Year><RecNum>21</RecNum><DisplayText>(21, 23)</DisplayText><record><rec-number>21</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">21</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Liu, YH</author><author>Ding, WH</author><author>Liu, J</author><author>Li, Q</author></authors></contributors><titles><title>Comparison of the differences in cephalometric parameters after active orthodontic treatment applying mini-screw implants or transpalatal arches in adult patients with bialveolar dental protrusion</title><secondary-title>Journal of oral rehabilitation</secondary-title></titles><periodical><full-title>Journal of oral rehabilitation</full-title></periodical><pages>687-695</pages><volume>36</volume><number>9</number><dates><year>2009</year></dates><isbn>1365-2842</isbn><urls></urls></record></Cite><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">23</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sandler, Jonathan</author><author>Murray, Alison</author><author>Thiruvengkatachari, Badri</author><author>Gutierrez, Rodrigo</author><author>Speight, Paul</author><author>O'Brien, Kevin</author></authors></contributors><titles><title>Effectiveness of 3 methods of anchorage reinforcement for maximum anchorage in adolescents: A 3-arm

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reported the overall duration of treatment. Duration of the space closure was

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months { ADDIN EN.CITE

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one RCT { ADDIN EN.CITE

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reported on the number of visits, PARS score reduction and patient perception. Two studies { ADDIN EN.CITE

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YH</author><author>Ding, WH</author><author>Liu, J</author><author>Li,
Q</author></authors></contributors><titles><title>Comparison of the differences in
cephalometric parameters after active orthodontic treatment applying mini-screw
implants or transpalatal arches in adult patients with bialveolar dental
protrusion</title><secondary-title>Journal of oral rehabilitation</secondary-
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695</pages><volume>36</volume><number>9</number><dates><year>2009</yea
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2842</isbn><urls></urls></record></Cite><Cite><Author>Sandler</Author><Year>2
014</Year><RecNum>23</RecNum><record><rec-number>23</rec-
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title></titles><periodical><full-title>American Journal of Orthodontics and
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20</pages><volume>146</volume><number>1</number><dates><year>2014</yea
r></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}

provided brief reports about the adverse effect of interventions.

Risk of bias

In summary, out of the seven studies included in this review, four studies were assessed as having an overall high risk of bias { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}, while three studies were assessed as having an overall low risk of bias { ADDIN

EN.CITE { ADDIN EN.CITE.DATA }}. The assessment of the risk of bias in the RCTs is presented and summarised in figure 2.

The random sequence generation was adequate in all studies except for one study { ADDIN EN.CITE

<EndNote><Cite><Author>Basha</Author><Year>2010</Year><RecNum>20</RecNum><DisplayText>(20)</DisplayText><record><rec-number>20</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">20</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Basha, Asim Ghouse</author><author>Shantaraj, Ravi</author><author>Mogegowda, Shivalinga B</author></authors></contributors><titles><title>Comparative study between conventional en-masse retraction (sliding mechanics) and en-masse retraction using orthodontic micro implant</title><secondary-title>Implant dentistry</secondary-title></titles><periodical><full-title>Implant dentistry</full-title></periodical><pages>128-136</pages><volume>19</volume><number>2</number><dates><year>2010</year></dates><isbn>1056-6163</isbn><urls></urls></record></Cite></EndNote>}.</EndNote><Cite><Author>Liu</Author><Year>2009</Year><RecNum>21</RecNum><DisplayText>(21, 22)</DisplayText><record><rec-number>21</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">21</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Liu, YH</author><author>Ding, WH</author><author>Liu, J</author><author>Li, Q</author></authors></contributors><titles><title>Comparison of the differences in cephalometric parameters after active orthodontic treatment applying mini-screw implants or transpalatal arches in adult patients with bialveolar dental protrusion</title><secondary-title>Journal of oral rehabilitation</secondary-title></titles><periodical><full-title>Journal of oral rehabilitation</full-title></periodical><pages>687-

Allocation concealment was graded as unclear in two studies { ADDIN EN.CITE

695</pages><volume>36</volume><number>9</number><dates><year>2009</year></dates><isbn>1365-2842</isbn><urls></urls></record></Cite><Cite><Author>Ma</Author><Year>2008</Year><RecNum>22</RecNum><record><rec-number>22</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">22</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ma, Junqing</author><author>Wang, Lin</author><author>Zhang, Weibing</author><author>Chen, Wenjing</author><author>Zhao, Chunyang</author><author>Smales, Roger J</author></authors></contributors><titles><title>Comparative evaluation of micro-implant and headgear anchorage used with a pre-adjusted appliance system</title><secondary-title>European journal of orthodontics</secondary-title></titles><periodical><full-title>European journal of orthodontics</full-title></periodical><volume>30</volume><number>3</number><dates><year>2008</year></dates><isbn>0141-5387</isbn><urls></urls></record></Cite></EndNote>}

and a high risk of bias in one study { ADDIN EN.CITE <EndNote><Cite><Author>Basha</Author><Year>2010</Year><RecNum>20</RecNum><DisplayText>(20)</DisplayText><record><rec-number>20</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">20</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Basha, Asim Ghouse</author><author>Shantaraj, Ravi</author><author>Mogegowda, Shivalinga B</author></authors></contributors><titles><title>Comparative study between conventional en-masse retraction (sliding mechanics) and en-masse retraction using orthodontic micro implant</title><secondary-title>Implant dentistry</secondary-title></titles><periodical><full-title>Implant dentistry</full-title></periodical><pages>128-136</pages><volume>19</volume><number>2</number><dates><year>2010</year></dates><isbn>1056-6163</isbn><urls></urls></record></Cite></EndNote>}. In four studies { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}, the outcome assessors were

blinded. The remaining three studies were graded as having either a high risk of bias {
ADDIN EN.CITE

<EndNote><Cite><Author>Basha</Author><Year>2010</Year><RecNum>20</RecNum><DisplayText>(20, 21)</DisplayText><record><rec-number>20</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">20</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Basha, Asim Ghouse</author><author>Shantaraj, Ravi</author><author>Mogegowda, Shivalinga B</author></authors></contributors><titles><title>Comparative study between conventional en-masse retraction (sliding mechanics) and en-masse retraction using orthodontic micro implant</title><secondary-title>Implant dentistry</secondary-title></titles><periodical><full-title>Implant dentistry</full-title></periodical><pages>128-136</pages><volume>19</volume><number>2</number><dates><year>2010</year></dates><isbn>1056-

6163</isbn><urls></urls></record></Cite><Cite><Author>Liu</Author><Year>2009</Year><RecNum>21</RecNum><record><rec-number>21</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">21</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Liu, YH</author><author>Ding, WH</author><author>Liu, J</author><author>Li, Q</author></authors></contributors><titles><title>Comparison of the differences in cephalometric parameters after active orthodontic treatment applying mini-screw implants or transpalatal arches in adult patients with bialveolar dental protrusion</title><secondary-title>Journal of oral rehabilitation</secondary-title></titles><periodical><full-title>Journal of oral rehabilitation</full-title></periodical><pages>687-

695</pages><volume>36</volume><number>9</number><dates><year>2009</year></dates><isbn>1365-2842</isbn><urls></urls></record></Cite></EndNote>}

unclear risk of bias { ADDIN EN.CITE
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risk of bias in the completion of the outcome data reporting domain (Attrition bias) was low in all included studies except one trial { ADDIN EN.CITE <EndNote><Cite><Author>Upadhyay</Author><Year>2008</Year><RecNum>25</R ecNum><DisplayText>(25)</DisplayText><record><rec-number>25</rec-

number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">25</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Upadhyay, Madhur</author><author>Yadav, Sumit</author><author>Nagaraj, K</author><author>Patil, Sameer</author></authors></contributors><titles><title>Treatment effects of mini-implants for en-masse retraction of anterior teeth in bialveolar dental protrusion patients: a randomized controlled trial</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-title></titles><periodical><full-title>American Journal of Orthodontics and Dentofacial Orthopedics</full-title></periodical><pages>18-29.e1</pages><volume>134</volume><number>1</number><dates><year>2008</yea

r></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}.</p></div>
<div data-bbox="145 108 850 205" data-label="Text"><p>Selective reporting bias was assessed as being of low risk in three studies { ADDIN EN.CITE { ADDIN EN.CITE.DATA }} while the remaining studies were graded as having a high risk of selective reporting bias { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. In all the included studies no other potential sources of bias were identified.</p></div>
<div data-bbox="145 216 271 233" data-label="Section-Header"><h3>Meta-analysis</h3></div>
<div data-bbox="145 241 640 259" data-label="Section-Header"><h4><i>Mesial Movement of the upper first molars (anchorage loss)</i></h4></div>
<div data-bbox="145 267 851 625" data-label="Text"><p>Six RCTs { ADDIN EN.CITE { ADDIN EN.CITE.DATA }} appropriately reported the primary outcome, but at variable time point, and they were included in the meta-analysis analysis (Figure 3). Data from 241 participants were included in a random effects meta-analysis to assess the anchorage effectiveness of 250 miniscrews when compared with 134 conventional anchorage devices. The conventional methods included headgear, transpalatal arch, Nance appliances, banding of second molar and differential anchorage methods. The overall standard mean difference (SMD) of the anchorage loss between the main two groups was -2.05 mm in favour of miniscrews ((95% CI (-3.01) to (-1.09), P<0.001, I²= 89%, 6 RCTs)) which was higher when subgroup analysis comparing the miniscrews and TPA groups was undertaken ((SDM=(-3.13), 95% CI (-4.72) to (-1.55), P<0.001, I² 88%, 4 RCTs)). Sensitivity analysis indicated that, after exclusion of the studies with a high risk of bias { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}, the SMD was preserved at -1.82 mm in favour of miniscrews ((95% CI (-2.55) to (-1.09) P<0.001, I²= 81%, 3 RCTs)) (Figure 4).</p></div>
<div data-bbox="145 633 403 651" data-label="Section-Header"><h4><i>Overall duration of Treatment</i></h4></div>
<div data-bbox="145 659 850 702" data-label="Text"><p>The overall duration of the treatment was reported in two RCTs; one trial { ADDIN EN.CITE</p></div>
<div data-bbox="145 711 850 912" data-label="Text"><p><EndNote><Cite><Author>Liu</Author><Year>2009</Year><RecNum>21</RecNum><DisplayText>(21)</DisplayText><record><rec-number>21</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">21</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Liu,
YH</author><author>Ding,
WH</author><author>Liu,
J</author><author>Li,
Q</author></authors></contributors><titles><title>Comparison of the differences in cephalometric parameters after active orthodontic treatment applying mini-screw</p></div>
<div data-bbox="760 937 850 956" data-label="Page-Footer"><p>{PAGE }</p></div>

implants or transpalatal arches in adult patients with bialveolar dental protrusion</title><secondary-title>Journal of oral rehabilitation</secondary-title></titles><periodical><full-title>Journal of oral rehabilitation</full-title></periodical><pages>687-

695</pages><volume>36</volume><number>9</number><dates><year>2009</year></dates><isbn>1365-2842</isbn><urls></urls></record></Cite></EndNote>} had high risk of bias and it showed that there is statistically non-significant ($P > 0.05$) difference in terms of total treatment duration between miniscrews (25.65 ± 5.06 months) and TPA device (26.88 ± 6.54 months). Similarly, the second trial { ADDIN EN.CITE

<EndNote><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><DisplayText>(23)</DisplayText><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202"

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which has low risk of bias concluded that difference in the overall treatment duration was almost equal ($P > 0.05$) in those treated using miniscrews (26.83 months, 95% CI 8.5-45.16), Nance appliance (27.43 months, 95% CI 15.03-39.83) or Headgear appliance (28.01 months, 95% CI 17.46-38.51). Results from 105 participants (total of 78 miniscrews and 66 conventional anchorage appliances) were pooled in a fixed-

effect meta-analysis. The difference in the means of the treatment duration was -0.14 year (95% CI (-0.49) to 0.21, P= 0.95, I²= 0%) in favour of miniscrews (Figure 5). It was not possible to undertake a subgroup analysis as there was only two RCTs which measured this outcome.

Duration of space closure phase

The duration of space closure phase was reported in two RCTs { ADDIN EN.CITE <EndNote><Cite><Author>Basha</Author><Year>2010</Year><RecNum>20</RecNum><DisplayText>(20, 25)</DisplayText><record><rec-number>20</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">20</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Basha, Asim Ghouse</author><author>Shantaraj, Ravi</author><author>Mogegowda, Shivalinga B</author></authors></contributors><titles><title>Comparative study between conventional en-masse retraction (sliding mechanics) and en-masse retraction using orthodontic micro implant</title><secondary-title>Implant dentistry</secondary-title></titles><periodical><full-title>Implant dentistry</full-title></periodical><pages>128-136</pages><volume>19</volume><number>2</number><dates><year>2010</year></dates><isbn>1056-6163</isbn><urls></urls></record></Cite><Cite><Author>Upadhyay</Author><Year>2008</Year><RecNum>25</RecNum><record><rec-number>25</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">25</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Upadhyay, Madhur</author><author>Yadav, Sumit</author><author>Nagaraj, K</author><author>Patil, Sameer</author></authors></contributors><titles><title>Treatment effects of mini-implants for en-masse retraction of anterior teeth in bialveolar dental protrusion patients: a randomized controlled trial</title><secondary-title>American Journal of

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 title></titles><periodical><full-title>American Journal of Orthodontics and
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 e1</pages><volume>134</volume><number>1</number><dates><year>2008</yea
 r></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}, both
 with high risk of bias, hence, the data was assessed narratively. The first trial { ADDIN
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<EndNote><Cite><Author>Basha</Author><Year>2010</Year><RecNum>20</RecNu
 m><DisplayText>(20)</DisplayText><record><rec-number>20</rec-
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 136</pages><volume>19</volume><number>2</number><dates><year>2010</yea
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calculated the number of days required to close extraction spaces using miniscrews
 (182.43, SD 9.64 days) and TPA (181, SD 32.07 days) while the second trail { ADDIN
 EN.CITE

<EndNote><Cite><Author>Upadhyay</Author><Year>2008</Year><RecNum>25</R
 ecNum><DisplayText>(25)</DisplayText><record><rec-number>25</rec-
 number><foreign-keys><key app="EN" db-
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Number of visits

Only one study { ADDIN EN.CITE <EndNote><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><DisplayText>(23)</DisplayText><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">23</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sandler, Jonathan</author><author>Murray, Alison</author><author>Thiruvengkatachari, Badri</author><author>Gutierrez, Rodrigo</author><author>Speight, Paul</author><author>O'Brien, Kevin</author></authors></contributors><titles><title>Effectiveness of 3 methods of anchorage reinforcement for maximum anchorage in adolescents: A 3-arm multicenter randomized clinical trial</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-title></titles><periodical><full-title>American Journal of Orthodontics and Dentofacial Orthopedics</full-title></periodical><pages>10-20</pages><volume>146</volume><number>1</number><dates><year>2014</year></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>} reported on the number of visits required to complete the treatment using different anchorage systems. Participants from the miniscrews arm completed their treatment

within 18.38 (SD 5.95) visits, this was shorter than those from the headgear and Nance appliance arms, 19.24 (SD 6.42) and 21.77 (SD 4.41) visits respectively.

Quality of the treatment

The quality of the treatment was assessed in one trial { ADDIN EN.CITE <EndNote><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><DisplayText>(23)</DisplayText><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">23</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sandler, Jonathan</author><author>Murray, Alison</author><author>Thiruvengkatachari, Badri</author><author>Gutierrez, Rodrigo</author><author>Speight, Paul</author><author>O'Brien, Kevin</author></authors></contributors><titles><title>Effectiveness of 3 methods of anchorage reinforcement for maximum anchorage in adolescents: A 3-arm multicenter randomized clinical trial</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-title></titles><periodical><full-title>American Journal of Orthodontics and Dentofacial Orthopedics</full-title></periodical><pages>10-20</pages><volume>146</volume><number>1</number><dates><year>2014</year></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>} using Peer Assessment Rating index (PAR index). Participants treated using miniscrews as an anchorage appliance had the highest PAR score (26.59, SD 13.82), followed by those treated by Nance appliance (25.69, SD 11.47) and headgear (21.26, SD 10.61). In comparison with headgear group, there was -3.97 and -1.24 PAR points in favour of miniscrews and Nance appliance groups respectively. The difference in PAR scoring between headgear and miniscrews groups was significant ($P<0.05$).

Patient perception and adverse effects

Only one study { ADDIN EN.CITE <EndNote><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><DisplayText>(23)</DisplayText><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-

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of anchorage reinforcement for maximum anchorage in adolescents: A 3-arm
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Dentofacial Orthopedics</full-title></periodical><pages>10-
20</pages><volume>146</volume><number>1</number><dates><year>2014</yea
r></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}

reported on pain perception using miniscrews, Nance and headgear appliances. Using
6-point Likert scale, Sandler and colleagues { ADDIN EN.CITE
<EndNote><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</Rec
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number><foreign-keys><key app="EN" db-
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Jonathan</author><author>Murray, Alison</author><author>Thiruvengkatachari,
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20</pages><volume>146</volume><number>1</number><dates><year>2014</yea

r></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}

found that participants had very mild level of discomfortability during placement and on removal of both miniscrews and Nance appliances. The authors also found that the participants' free text comments were almost always positive toward miniscrews, unlike Nance and headgear. Nine out of ten participants (90%) recommended miniscrews to their peers. For those who had been treated using headgear and Nance appliance, the figures were approximately 77% and 57% respectively. Comfort, compliance and convenience with the headgear appliance was poor among adolescent patients.

Two trials reported briefly on the adverse effect { ADDIN EN.CITE <EndNote><Cite><Author>Liu</Author><Year>2009</Year><RecNum>21</RecNum><DisplayText>(21, 23)</DisplayText><record><rec-number>21</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">21</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Liu, YH</author><author>Ding, WH</author><author>Liu, J</author><author>Li, Q</author></authors></contributors><titles><title>Comparison of the differences in cephalometric parameters after active orthodontic treatment applying mini-screw implants or transpalatal arches in adult patients with bialveolar dental protrusion</title><secondary-title>Journal of oral rehabilitation</secondary-title></titles><periodical><full-title>Journal of oral rehabilitation</full-title></periodical><pages>687-695</pages><volume>36</volume><number>9</number><dates><year>2009</year></dates><isbn>1365-

2842</isbn><urls></urls></record></Cite><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">23</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sandler, Jonathan</author><author>Murray, Alison</author><author>Thiruvengkatachari,

Badri</author><author>Gutierrez, Rodrigo</author><author>Speight, Paul</author><author>O'Brien, Kevin</author></authors></contributors><titles><title>Effectiveness of 3 methods of anchorage reinforcement for maximum anchorage in adolescents: A 3-arm multicenter randomized clinical trial</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-title></titles><periodical><full-title>American Journal of Orthodontics and Dentofacial Orthopedics</full-title></periodical><pages>10-20</pages><volume>146</volume><number>1</number><dates><year>2014</year></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}. Both

reported no serious harms secondary to interventions. However, in one trial { ADDIN EN.CITE

<EndNote><Cite><Author>Liu</Author><Year>2009</Year><RecNum>21</RecNum><DisplayText>(21)</DisplayText><record><rec-number>21</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">21</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Liu, YH</author><author>Ding, WH</author><author>Liu, J</author><author>Li, Q</author></authors></contributors><titles><title>Comparison of the differences in cephalometric parameters after active orthodontic treatment applying mini-screw implants or transpalatal arches in adult patients with bialveolar dental protrusion</title><secondary-title>Journal of oral rehabilitation</secondary-title></titles><periodical><full-title>Journal of oral rehabilitation</full-title></periodical><pages>687-695</pages><volume>36</volume><number>9</number><dates><year>2009</year></dates><isbn>1365-2842</isbn><urls></urls></record></Cite></EndNote>}, 8

miniscrews failed throughout the treatment which were replaced two months later without complications. In the second trial { ADDIN EN.CITE <EndNote><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><DisplayText>(23)</DisplayText><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202"

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one miniscrews fractured during its insertion but it was left it in situ without complications, the authors did not report whether replacement was undertaken immediately or at later stage. Table 2 represent the summary of findings table for the main outcomes of this systematic review.

Discussion

Overall, the findings from this review suggest that there is moderate quality evidence that reinforcement of anchorage using mechanically retained miniscrews are more clinically efficient than any conventional anchorage devices.

A meta-analysis of the pooled data found a significant difference between miniscrews on one hand and conventional anchorage devices/ mechanics on the other hand, 2.05 mm in favour of miniscrews. Excluding studies with low risk of bias from the data synthesis still showed a similar finding (1.82mm). Jambi and colleagues { ADDIN EN.CITE

<EndNote><Cite><Author>Jambi</Author><Year>2014</Year><RecNum>13</RecNum><DisplayText>(13)</DisplayText><record><rec-number>13</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">13</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jambi, Safa</author><author>Walsh, Tanya</author><author>Sandler, Jonathan</author><author>Benson, Philip E</author><author>Skeggs, Richard M</author><author>O'Brien, Kevin D</author></authors></contributors><titles><title>Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-title></periodical><dates><year>2014</year></dates><isbn>1465-1858</isbn></urls></record></Cite></EndNote>} in their review found surgical anchorage devices result in less anchorage loss (1.68 mm, 95% CI 2.27-1.09) than conventional approaches. Although they included in their review osseointegrated implants, their estimate did not differ significantly from our review estimate. Moreover, in Jambi et al. study { ADDIN EN.CITE <EndNote><Cite><Author>Jambi</Author><Year>2014</Year><RecNum>13</RecNum><DisplayText>(13)</DisplayText><record><rec-number>13</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202"

timestamp="1521310851">13</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jambi, Safa</author><author>Walsh, Tanya</author><author>Sandler, Jonathan</author><author>Benson, Philip E</author><author>Skeggs, Richard M</author><author>O'Brien, Kevin D</author></authors></contributors><titles><title>Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-title></periodical><dates><year>2014</year></dates><isbn>1465-

1858</isbn><urls></urls></record></Cite></EndNote>}, the pooled data from the high-quality RCTs showed a mean difference of 2.17 mm (95% CI, 2.58-1.77) in favour of skeletal anchorage which is slightly higher than our findings. A similar systematic review was undertaken by Papadopoulos and co-workers { ADDIN EN.CITE <EndNote><Cite><Author>Papadopoulos</Author><Year>2011</Year><RecNum>26 </RecNum><DisplayText>(26)</DisplayText><record><rec-number>26</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202"

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976</pages><volume>90</volume><number>8</number><dates><year>2011</year></dates><isbn>0022-0345</isbn><urls></urls></record></Cite></EndNote>}, included five cohort studies and three RCTs, they concluded that miniscrews were more effective than conventional anchorage methods (2.4 mm, 95% CI 1.8-2.9 in favour of miniscrews). However, Papadopoulos and colleagues included studies with high risk of bias which could affect robustness of their findings. Another systematic review that investigated anchorage effectiveness of orthodontic implants (not

mechanically miniscrews) and headgear was undertaken by Li and colleagues { ADDIN EN.CITE

<EndNote><Cite><Author>Li</Author><Year>2011</Year><RecNum>27</RecNum>
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QS</author></authors></contributors><titles><title>Comparison of anchorage
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r></dates><isbn>0003-3219</isbn><urls></urls></record></Cite></EndNote>}. The

result of their search included four RCTs, one prospective cohort study and three retrospective studies; however, they pooled the data from two studies only. The estimated mean difference was 1.34 mm (95% CI 2.02-0.67) in favour of implants which is slightly lower than that in our findings.

In our review, some of the secondary outcomes were reported in two studies with

variable quality { ADDIN EN.CITE

<EndNote><Cite><Author>Liu</Author><Year>2009</Year><RecNum>21</RecNum>
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YH</author><author>Ding, WH</author><author>Liu, J</author><author>Li, Q</author></authors></contributors><titles><title>Comparison of the differences in cephalometric parameters after active orthodontic treatment applying mini-screw implants or transpalatal arches in adult patients with bialveolar dental protrusion</title><secondary-title>Journal of oral rehabilitation</secondary-title></titles><periodical><full-title>Journal of oral rehabilitation</full-title></periodical><pages>687-695</pages><volume>36</volume><number>9</number><dates><year>2009</year></dates><isbn>1365-2842</isbn><urls></urls></record></Cite><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">23</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sandler, Jonathan</author><author>Murray, Alison</author><author>Thiruvengkatachari, Badri</author><author>Gutierrez, Rodrigo</author><author>Speight, Paul</author><author>O'Brien, Kevin</author></authors></contributors><titles><title>Effectiveness of 3 methods of anchorage reinforcement for maximum anchorage in adolescents: A 3-arm multicenter randomized clinical trial</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-title></titles><periodical><full-title>American Journal of Orthodontics and Dentofacial Orthopedics</full-title></periodical><pages>10-20</pages><volume>146</volume><number>1</number><dates><year>2014</year></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}. Failure rate of the miniscrews was variable among the included studies but overall it was low and comparable to the published data { ADDIN EN.CITE <EndNote><Cite><Author>Alharbi</Author><Year>2018</Year><RecNum>31</RecNum><DisplayText>(31)</DisplayText><record><rec-number>31</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202"

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eight miniscrews were failed and the operator waited for 2 months before replacing them to allow bone healing at the insertion site; this could increase both overall treatment duration, space closure phase durations and overall cost of treatment. Nevertheless, the data extracted from these two studies { ADDIN EN.CITE

<EndNote><Cite><Author>Liu</Author><Year>2009</Year><RecNum>21</RecNum><DisplayText>(21, 23)</DisplayText><record><rec-number>21</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">21</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Liu, YH</author><author>Ding, WH</author><author>Liu, J</author><author>Li, Q</author></authors></contributors><titles><title>Comparison of the differences in cephalometric parameters after active orthodontic treatment applying mini-screw implants or transpalatal arches in adult patients with bialveolar dental protrusion</title><secondary-title>Journal of oral rehabilitation</secondary-title></titles><periodical><full-title>Journal of oral rehabilitation</full-title></periodical><pages>687-695</pages><volume>36</volume><number>9</number><dates><year>2009</year></dates><isbn>1365-2842</isbn><urls></urls></record></Cite><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><record><rec-number>23</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">23</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sandler, Jonathan</author><author>Murray, Alison</author><author>Thiruvengkatachari, Badri</author><author>Gutierrez, Rodrigo</author><author>Speight, Paul</author><author>O'Brien, Kevin</author></authors></contributors><titles><title>Effectiveness of 3 methods of anchorage reinforcement for maximum anchorage in adolescents: A 3-arm multicenter randomized clinical trial</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-

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revealed that treatment duration was shorter when miniscrews as anchorage device were used, however, this was not statistically significant. Likewise, duration of space closure phase was almost identical among those treated with miniscrews or other means of anchorage provision as reported by two low quality trials { ADDIN EN.CITE

<EndNote><Cite><Author>Basha</Author><Year>2010</Year><RecNum>20</RecNum><DisplayText>(20, 25)</DisplayText><record><rec-number>20</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202"

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Sameer</author></authors></contributors><titles><title>Treatment effects of mini-implants for en-masse retraction of anterior teeth in bialveolar dental protrusion

patients: a randomized controlled trial</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-title></titles><periodical><full-title>American Journal of Orthodontics and Dentofacial Orthopedics</full-title></periodical><pages>18-29. e1</pages><volume>134</volume><number>1</number><dates><year>2008</year></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}. It is

worth mentioning that the loss of anchorage in the conventional anchorage samples resulted in a smaller amount of extraction space left for incisor retraction, hence, the time required for space closure could be shortened. If the above mentioned point and the extra waiting time required to replace failed miniscrews were taken in consideration, theoretically, miniscrews implication on treatment duration would be accentuated. Jambi and co-workers { ADDIN EN.CITE <EndNote><Cite><Author>Jambi</Author><Year>2014</Year><RecNum>13</RecNum><DisplayText>(13)</DisplayText><record><rec-number>13</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">13</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jambi, Safa</author><author>Walsh, Tanya</author><author>Sandler, Jonathan</author><author>Benson, Philip E</author><author>Skeggs, Richard M</author><author>O'Brien, Kevin D</author></authors></contributors><titles><title>Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-title></periodical><dates><year>2014</year></dates><isbn>1465-1858</isbn><urls></urls></record></Cite></EndNote>} found similar outcome and they indicated that orthodontic treatment reinforced with surgical anchorage was on average shorter by 0.15 year (0.37 years shorter to 0.07 years longer) compared to the group treated with conventional anchorage, however, it is worth noticing that the pooled the data in that review were collected from three studies, two of them used palatal implants { ADDIN EN.CITE

<EndNote><Cite><Author>Borsos</Author><Year>2012</Year><RecNum>28</RecNum><DisplayText>(28, 29)</DisplayText><record><rec-number>28</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310852">28</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Borsos, Gabriella</author><author>Vokó, Zoltan</author><author>Gredes, Tomasz</author><author>Kunert-Keil, Christiane</author><author>Vegh, Andras</author></authors></contributors><titles><title>Tooth movement using palatal implant supported anchorage compared to conventional dental anchorage</title><secondary-title>Annals of Anatomy-Anatomischer Anzeiger</secondary-title></titles><periodical><full-title>Annals of Anatomy-Anatomischer Anzeiger</full-title></periodical><pages>556-560</pages><volume>194</volume><number>6</number><dates><year>2012</year></dates><isbn>0940-9602</isbn><urls></urls></record></Cite><Cite><Author>Sandler</Author><Year>2008</Year><RecNum>29</RecNum><record><rec-number>29</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310852">29</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sandler, Jonathan</author><author>Benson, Philip E</author><author>Doyle, Peter</author><author>Majumder, Arun</author><author>O'Dwyer, Jonathan</author><author>Speight, Paul</author><author>Thiruvengkatachari, Badri</author><author>Tinsley, David</author></authors></contributors><titles><title>Palatal implants are a good alternative to headgear: a randomized trial</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-title></titles><periodical><full-title>American Journal of Orthodontics and Dentofacial Orthopedics</full-title></periodical><pages>51-57</pages><volume>133</volume><number>1</number><dates><year>2008</year></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>} and

only one study used miniscrews { ADDIN EN.CITE
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 In our review, participants treated using miniscrews attended 2-3 visits fewer than
 those treated using other anchorage approaches { ADDIN EN.CITE
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20</pages><volume>146</volume><number>1</number><dates><year>2014</year></dates><isbn>0889-5406</isbn><urls></urls></record></Cite></EndNote>}. This is contradicting with the findings of the Cochrane review { ADDIN EN.CITE <EndNote><Cite><Author>Jambi</Author><Year>2014</Year><RecNum>13</RecNum><DisplayText>(13)</DisplayText><record><rec-number>13</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310851">13</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Jambi, Safa</author><author>Walsh, Tanya</author><author>Sandler, Jonathan</author><author>Benson, Philip E</author><author>Skeggs, Richard M</author><author>O'Brien, Kevin D</author></authors></contributors><titles><title>Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods</title><secondary-title>The Cochrane Library</secondary-title></titles><periodical><full-title>The Cochrane Library</full-title></periodical><dates><year>2014</year></dates><isbn>1465-1858</isbn><urls></urls></record></Cite></EndNote>} in which the outcomes of one study { ADDIN EN.CITE <EndNote><Cite><Author>Sandler</Author><Year>2008</Year><RecNum>29</RecNum><DisplayText>(29)</DisplayText><record><rec-number>29</rec-number><foreign-keys><key app="EN" db-id="eereerpwwppee0eva0pxxd2z00x05vzsf202" timestamp="1521310852">29</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Sandler, Jonathan</author><author>Benson, Philip E</author><author>Doyle, Peter</author><author>Majumder, Arun</author><author>O'Dwyer, Jonathan</author><author>Speight, Paul</author><author>Thiruvengkatachari, Badri</author><author>Tinsley, David</author></authors></contributors><titles><title>Palatal implants are a good alternative to headgear: a randomized trial</title><secondary-title>American Journal of Orthodontics and Dentofacial Orthopedics</secondary-

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indicated that treatment takes 7 visits more to be completed by surgical anchorage, although visits required for surgical healing of mid-palatal implants (osseointegration) were not counted.

In our review, one study { ADDIN EN.CITE <EndNote><Cite><Author>Sandler</Author><Year>2014</Year><RecNum>23</RecNum><DisplayText>(23)</DisplayText><record><rec-number>23</rec-

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reported on patients' perception and found that patients had positive perception about miniscrews unlike headgear and Nance appliance. This is unlike the outcomes of Jambi et al. review { ADDIN EN.CITE <EndNote><Cite><Author>Jambi</Author><Year>2014</Year><RecNum>13</RecNum><DisplayText>(13)</DisplayText><record><rec-number>13</rec-

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reported that participants experienced more discomfort with bone anchorage
devices, however, both studies used surgical implants which makes the comparison
with our review not possible. Furthermore, there is limited evidence that the quality
of the occlusal outcomes is better when miniscrews were used as an anchorage device
in comparison to other anchorage appliances { ADDIN EN.CITE
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Recommendations for clinical practice

Overall, data analysis of this review shows that there is moderate anchorage favouring miniscrews in providing anchorage over conventional methods. There is also a limited evidence suggesting that treatment with miniscrews provides better occlusal outcomes and is better tolerated by patients than headgear or Nance appliances. Limited evidence suggesting that there is no significant difference in terms of overall treatment duration, space closure duration, adverse side effect, space closure duration and number of orthodontic visit. None of the included trials reported on the cost-effectiveness of the different anchorage devices.

Implications for research

There is a need for further long-term and high quality RCT to report on number of the required orthodontic appointments, failure rate of different anchorage devices, cost efficiency, discomfort and related quality of life issues.

Conclusion

There is a moderate quality evidence suggesting that miniscrews are statistically more effective than conventional anchorage devices, preserving 2.206mm of space, this effect might be considered clinically significant. Limited evidence suggesting that there is no significant difference in terms of overall treatment duration, space closure duration, adverse side effect, space closure duration and number of orthodontic visit. Additionally, there is limited evidence suggesting that the occlusal outcomes and patient perception secondary to anchorage reinforcement using miniscrews as anchorage appliance are better than any other anchorage appliances. However, due to the high level of statistical and clinical heterogeneity, this finding should be interpreted with caution. High quality RCTs with large sample size would give more conclusive evidence.

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The authors would like to thank Dr Hisham Mohammed from Glasgow Dental Academy for his help in undertaking this review.

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References

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